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(54) **TEXTILE CASCADE ASSEMBLY**

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CPC F02K 1/72; F02K 1/70; F02K 1/62; F02K 1/625; F05D 2240/129
See application file for complete search history.

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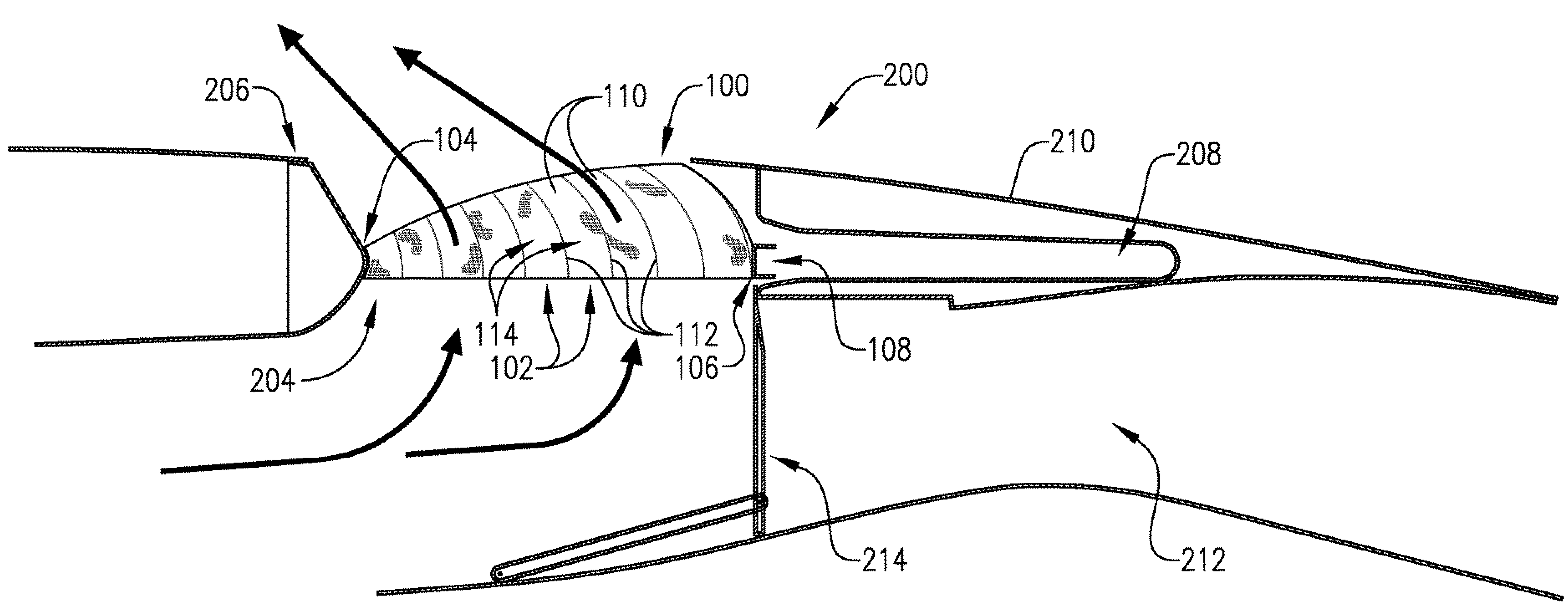
(57) **ABSTRACT**

A cascade assembly for a thrust reverser of an aircraft engine. The cascade broadly comprises a number of vanes formed of a pliable material and shiftable between a collapsed position when the thrust reverser is in a stowed configuration and a distended position when the thrust reverser is in a deployed configuration to redirect fan duct flow in a reverse thrust flow opening created by the thrust reverser.

7 Claims, 7 Drawing Sheets



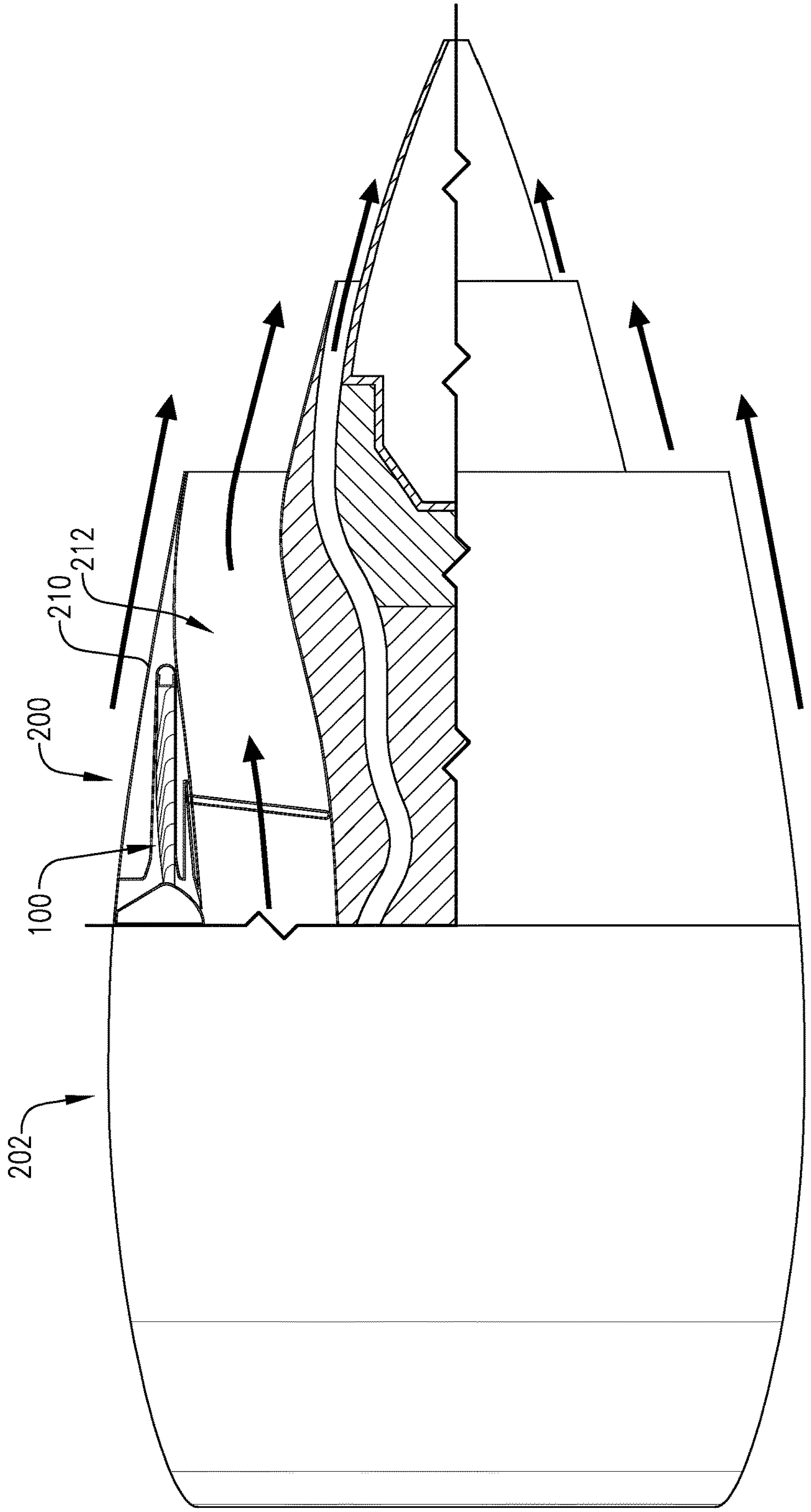


FIG. 1

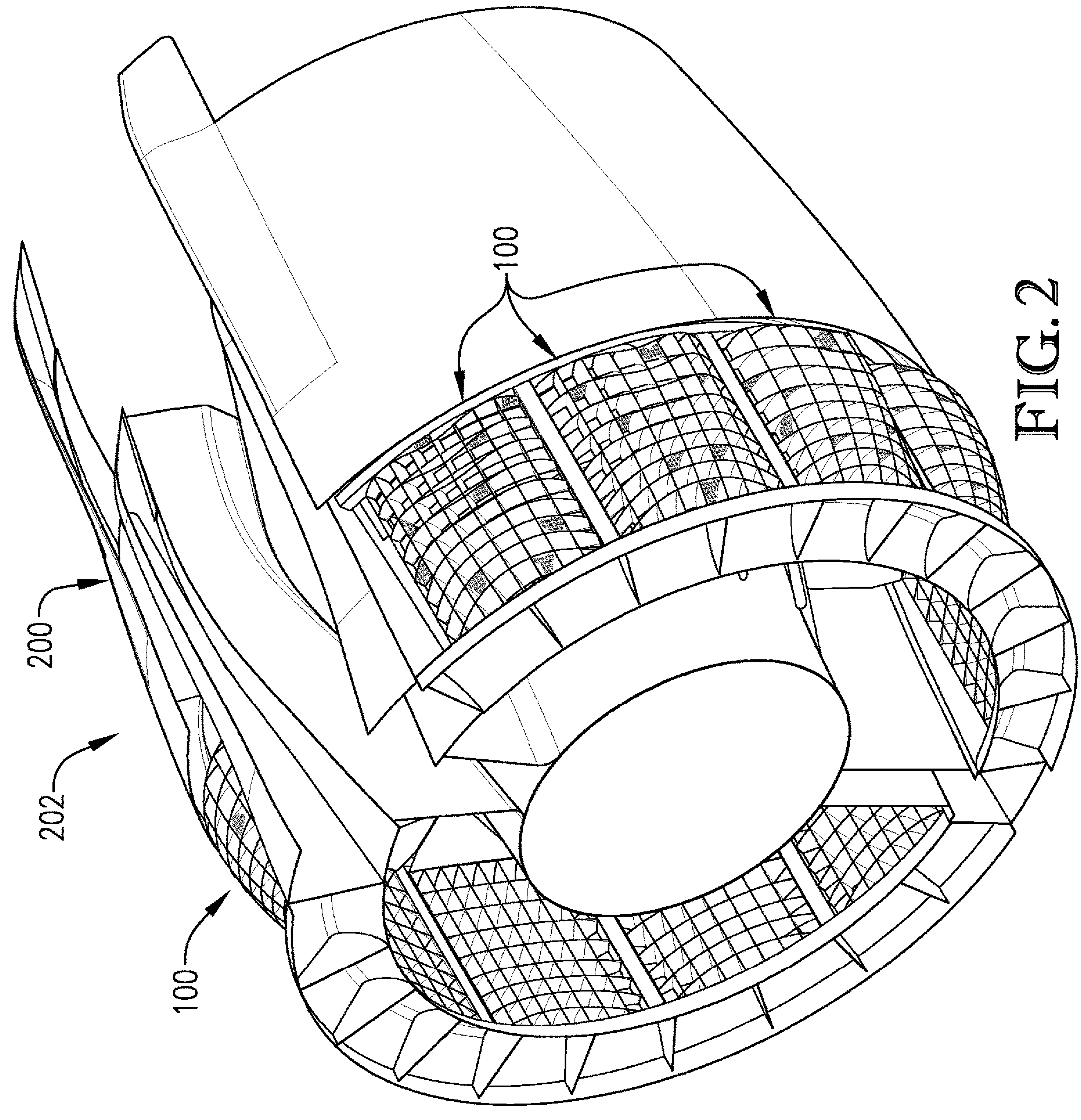


FIG. 2

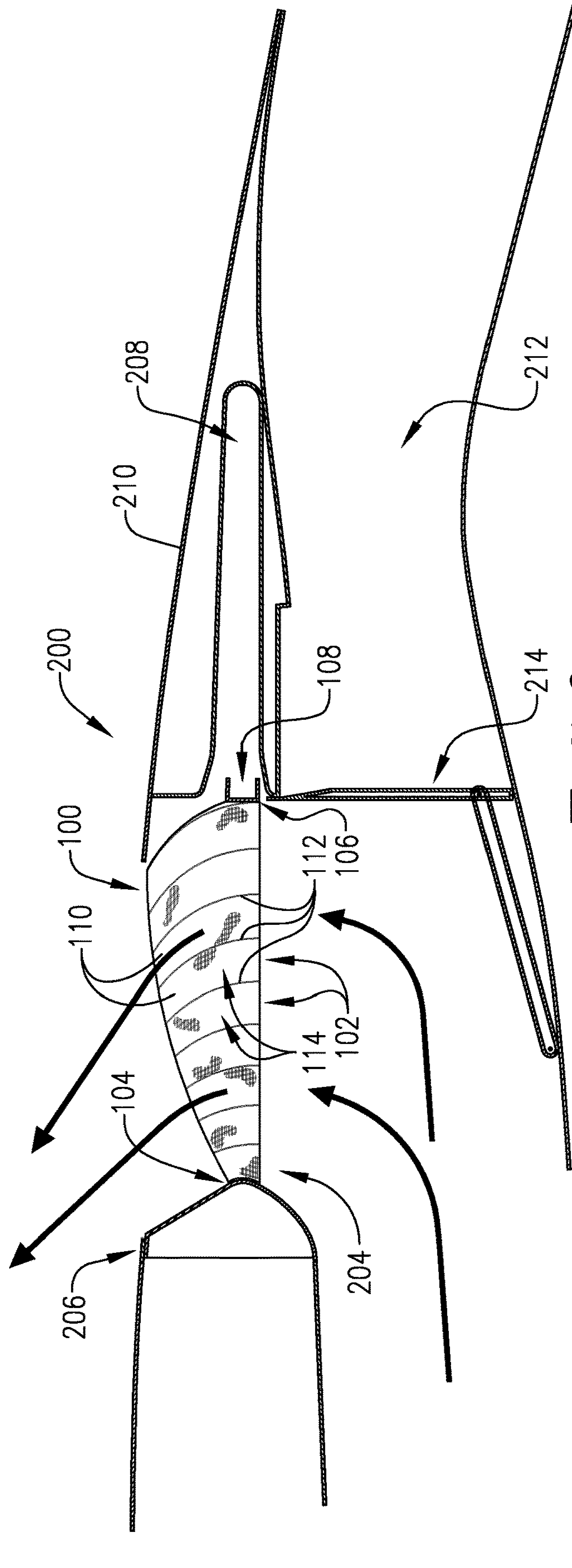


FIG. 3

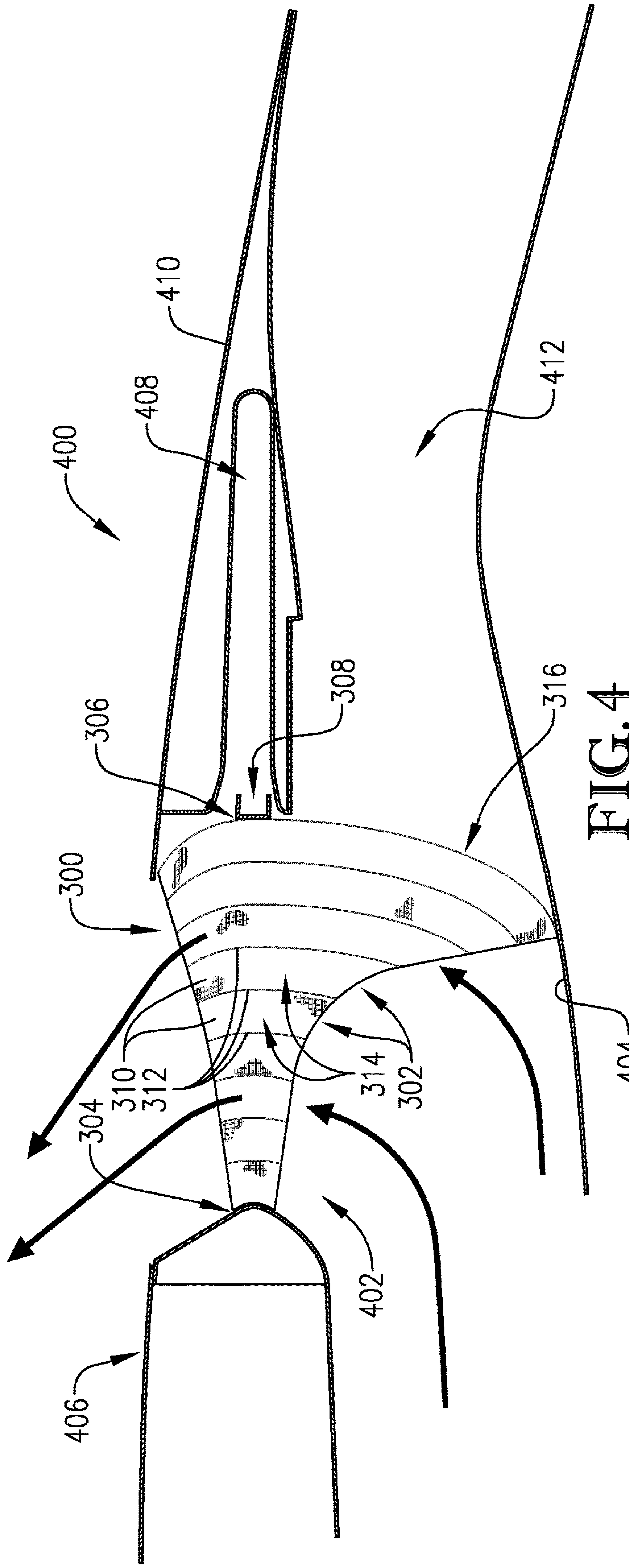


FIG. 4

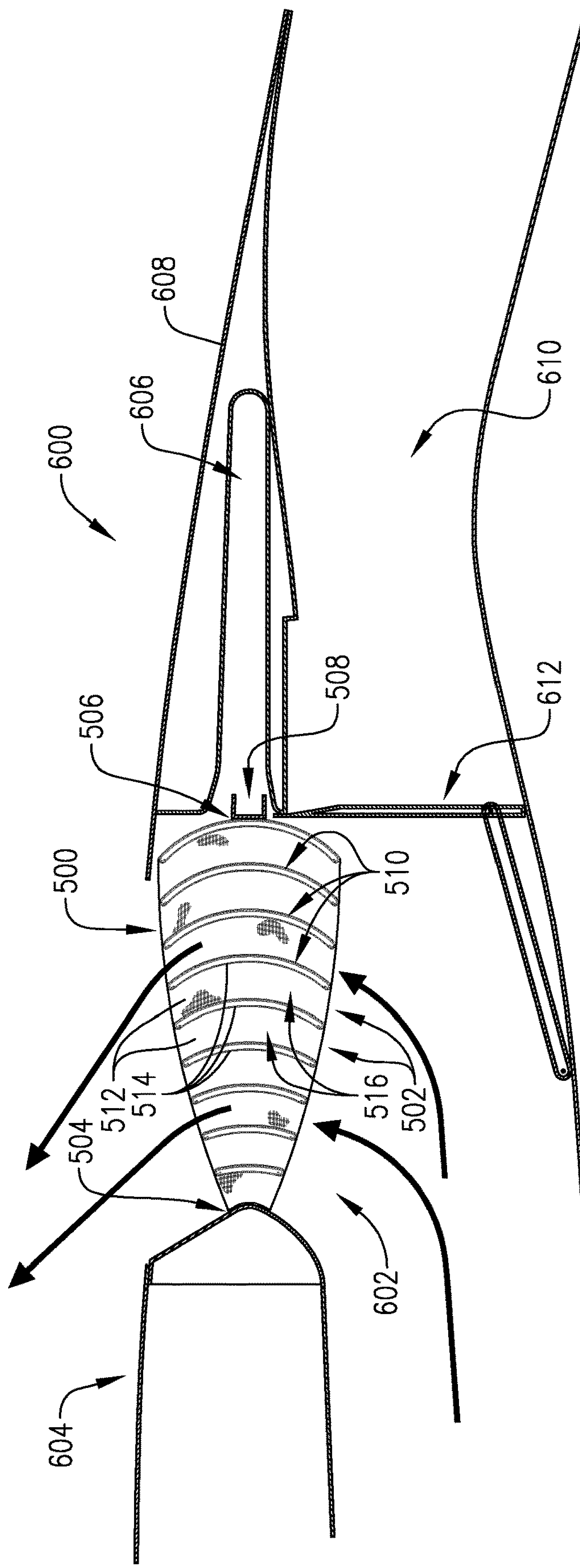


FIG. 5

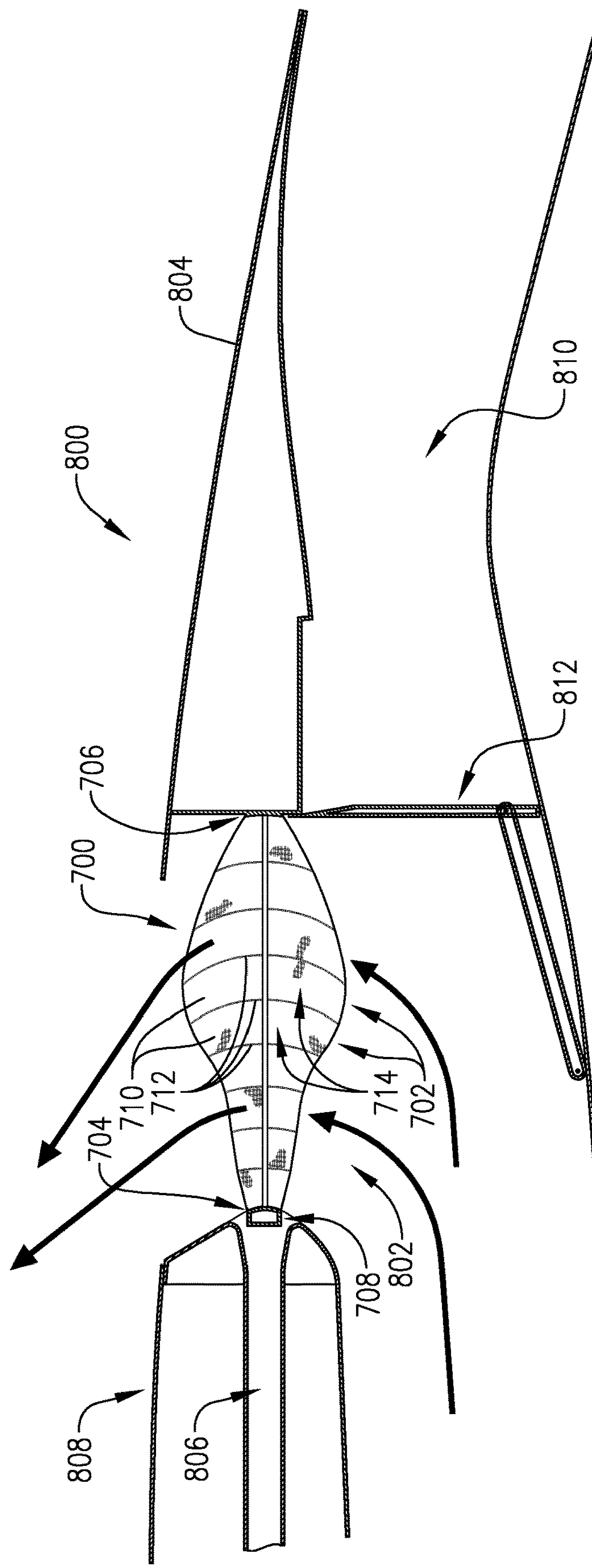
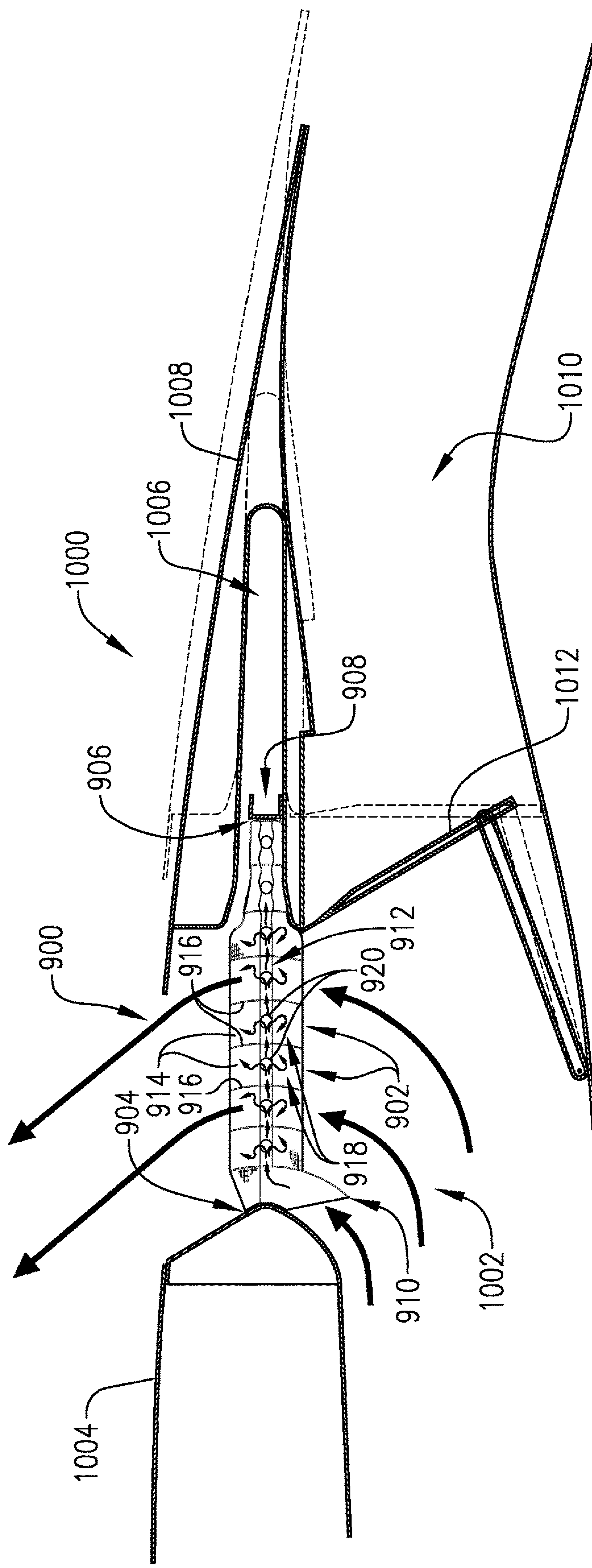


FIG. 6


1000
1002
1004
1006
1008
1010
1012
900
902
904
906
908
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918
920

FIG. 7

TEXTILE CASCADE ASSEMBLY

BACKGROUND

Thrust reverser cascade assemblies increase the size and weight of aircraft engine nacelles, which adds aerodynamic drag. Cascade assemblies also produce limited reverse thrust. Furthermore, they require complicated mounting structures and are difficult to fabricate.

SUMMARY

Embodiments of the invention solve the above-mentioned problems and other problems and provide a distinct advancement in the art of thrust reverser cascade assemblies. More particularly, the invention provides a lightweight, textile cascade assembly configured to pliably collapse into a small volume when not in use. The cascade assembly is also easier to manufacture and install in a thrust reverser.

An embodiment of the invention is a cascade assembly broadly comprising a number of vanes, a forward connection point, an aft connection point, and a rear support member. The cascade assembly may be part of a thrust reverser configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening.

The vanes include a number of longitudinal panels and a number of lateral panels and form several channels for redirecting fan duct flow through the reverse thrust flow opening when the thrust reverser is in a deployed configuration and the vanes are distended. The vanes are formed of a pliable textile material.

The longitudinal panels extend from a forward end of the cascade assembly to an aft end of the cascade assembly. The longitudinal panels may be substantially straight or may be curved to increase a lateral component of the fan duct flow.

The lateral panels extend between opposite sides of the cascade assembly. The lateral panels are curved to redirect the fan duct flow at least partially forward out of the reverse thrust flow opening.

The forward connection point connects the vanes to a forward structure of the thrust reverser. The aft connection point connects the vanes to the rear support member. The aft connection point may have a fixed spacing from the forward connection point.

The rear support member is connected to the vanes at the aft connection point and may be positioned in an open-ended chamber of a sleeve of the thrust reverser. The rear support member may be configured to move relative to the sleeve when the thrust reverser is actuated to a deployed configuration. To that end, the rear support member may translate within the open-ended chamber during thrust reverser actuation.

In use, the cascade assembly redirects fan duct flow when the thrust reverser is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve shifts rearward relative to the forward structure to create the reverse thrust flow opening and expose the cascade assembly in the reverse thrust flow opening. A blocker door also blocks off a forward thrust flow path to redirect fan duct flow to the reverse thrust flow opening. The fan duct flow passes through the channels to distend the vanes. The distended vanes turn the fan duct flow to have a forward component, thereby decelerating the aircraft.

The vanes collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve shifts toward the forward structure to close off the reverse thrust flow opening. The pliable textile material allows the vanes to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber. To that end, the vanes may collapse along a single plane or axis or in at least two directions.

Another embodiment of the invention is a cascade assembly broadly comprising a number of vanes, a forward connection point, an aft connection point, and a rear support member. The cascade assembly may be part of a thrust reverser configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening.

The vanes include a number of longitudinal panels and a number of lateral panels. The vanes form several channels for redirecting fan duct flow through the reverse thrust flow opening when the thrust reverser is in a deployed configuration and the vanes are distended.

Some of the vanes (aft vanes in particular) are closed-end cells configured to inflate instead of allowing duct flow to pass through. Some of the lateral panels of the closed-end cells form a blocker panel configured to contact an inner wall of the thrust reverser when the closed-end cells are inflated. The blocker panel aids in cascade distension, flow redirection, and cascade support.

In use, the cascade assembly redirects fan duct flow when the thrust reverser is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve shifts rearward relative to the forward structure to create the reverse thrust flow opening and expose the cascade assembly in the reverse thrust flow opening. Some of the vanes inflate so that the blocker panel blocks off a forward thrust flow path to redirect fan duct flow to the reverse thrust flow opening. The fan duct flow passes through the channels to distend the vanes, or they may be distended due to the aforementioned vane inflation. The distended vanes turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The vanes collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve shifts toward the forward structure to close off the reverse thrust flow opening. The pliable textile material allows the vanes to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber.

Another embodiment of the invention is a cascade assembly constructed broadly comprising a number of vanes, a forward connection point, an aft connection point, a rear support member, and a number of biasing members. The cascade assembly may be part of a thrust reverser configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening.

The vanes include a number of longitudinal panels and a number of lateral panels. The vanes form several channels for redirecting fan duct flow through the reverse thrust flow opening when the thrust reverser is in a deployed configuration and the vanes are distended.

The biasing members may be spaced apart from each other throughout the vanes and may be sewn in or embedded in the lateral panels. The biasing members may be compressed, coiled, or stressed when the vanes are stowed. The biasing members may be leaf springs, coil springs, torsion springs, or the like. The biasing members urge the vanes to a distended position when the thrust reverser is deployed. The biasing members may also stabilize and reinforce the longitudinal panels and lateral panels and reinforce a shape of the lateral panels.

In use, the cascade assembly redirects fan duct flow when the thrust reverser is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve shifts rearward relative to the forward structure to create the reverse thrust flow opening and expose the cascade assembly in the reverse thrust flow opening. A blocker door also blocks off a forward thrust flow path to redirect fan duct flow to the reverse thrust flow opening. The biasing members expand, uncoil, or relax to distend the vanes in the reverse thrust flow opening. The distended vanes turn the fan duct flow to have a forward component, thereby decelerating the aircraft.

The vanes collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve shifts toward the forward structure to close off the reverse thrust flow opening. The pliable textile material allows the vanes to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber. The biasing members are recompressed, recoiled, or restressed as the vanes are stowed.

Another embodiment of the invention is a cascade assembly broadly comprising a number of vanes, a forward connection point, an aft connection point, and a forward support member. The cascade assembly may be part of a thrust reverser configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening.

The vanes include a number of longitudinal panels and a number of lateral panels. The vanes form several channels for redirecting fan duct flow through the reverse thrust flow opening when the thrust reverser is in a deployed configuration and the vanes are distended.

The forward support member is connected to the vanes at the forward connection point and is positioned in an open-ended chamber of a forward structure of the thrust reverser. The forward support member is configured to move at least somewhat in unison with the sleeve of the thrust reverser when the thrust reverser is actuated to a deployed configuration. To that end, the forward support member may translate within the open-ended chamber during thrust reverser actuation.

In use, the cascade assembly redirects fan duct flow when the thrust reverser is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve shifts rearward relative to the forward structure to create the reverse thrust flow opening and to draw the cascade assembly out of the open-ended chamber of the forward structure. A blocker door also blocks off a forward thrust flow path to redirect fan duct flow to the reverse thrust flow opening. The fan duct flow passes through the channels to distend the vanes. The distended vanes turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The vanes collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve shifts toward the forward structure to close off the reverse thrust flow opening. The pliable textile material allows the vanes to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber. The pliable textile material reduces the storage space needed, which allows the vanes to be stowed in the forward structure and decreases the overall size of the engine's nacelle.

Another embodiment of the invention is a cascade assembly broadly comprising a number of vanes, a forward connection point, an aft connection point, a rear support member, an inflation scoop, and an inflation tube. The cascade assembly may be part of a thrust reverser configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening.

The vanes include a number of longitudinal panels and a number of lateral panels. The vanes form several channels for redirecting fan duct flow through the reverse thrust flow opening when the thrust reverser is in a deployed configuration and the of vanes are distended.

The inflation scoop is a modified vane near the front of the cascade assembly and connected to the inflation tube for directing some fluid flow into the inflation tube. To that end, the inflation scoop may extend lower than the other vanes near the forward support structure.

The inflation tube is fluidly connected between the inflation scoop and some of the other vanes. To that end, the inflation tube includes a number of openings for distributing the fluid flow collected by the inflation scoop to the connected vanes. In one embodiment, the inflation tube extends from the inflation scoop near the front of the cascade assembly to an aft end of the cascade assembly with the openings passing through certain longitudinal panels.

In use, the cascade assembly redirects fan duct flow when the thrust reverser is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve shifts rearward relative to the forward structure to create the reverse thrust flow opening and expose the cascade assembly in the reverse thrust flow opening. A blocker door also blocks off a forward thrust flow path to redirect fan duct flow to the reverse thrust flow opening. The inflation scoop directs some of the fan duct flow into the inflation tube. The inflation tube distributes the fan duct flow collected by the inflation scoop to some of the vanes via the openings to distend the vanes. The distended vanes turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The vanes, inflation scoop, and inflation tube collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve shifts toward the forward structure to close off the reverse thrust flow opening. The pliable textile material allows the of vanes, inflation scoop, and inflation tube to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber.

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Other aspects and advantages of the present invention will be apparent from the following detailed description of the preferred embodiments and the accompanying drawing figures.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

Embodiments of the present invention are described in detail below with reference to the attached drawing figures, wherein:

FIG. **1** is a partial cutaway elevation view of an aircraft engine comprising a thrust reverser including a textile cascade assembly constructed in accordance with an embodiment of the invention;

FIG. **2** is a perspective view of the aircraft engine of FIG. **1**;

FIG. **3** is a cutaway elevation view of the thrust reverser and textile cascade assembly of FIG. **1**;

FIG. **4** is a cutaway elevation view of a thrust reverser including a textile cascade assembly constructed in accordance with another embodiment of the invention;

FIG. **5** is a cutaway elevation view of a thrust reverser including a textile cascade assembly constructed in accordance with another embodiment of the invention;

FIG. **6** is a cutaway elevation view of a thrust reverser including a textile cascade assembly constructed in accordance with another embodiment of the invention; and

FIG. **7** is a cutaway elevation view of a thrust reverser including a textile cascade assembly constructed in accordance with another embodiment of the invention.

The drawing figures do not limit the present invention to the specific embodiments disclosed and described herein. The drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention.

DETAILED DESCRIPTION

The following detailed description of the invention references the accompanying drawings that illustrate specific embodiments in which the invention can be practiced. The embodiments are intended to describe aspects of the invention in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments can be utilized and changes can be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense. The scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

In this description, references to "one embodiment", "an embodiment", or "embodiments" mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to "one embodiment", "an embodiment", or "embodiments" in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, act, etc. described in one embodiment may also be included in other embodiments, but is not necessarily included. Thus, the present technology can include a variety of combinations and/or integrations of the embodiments described herein. Directional terms such as "longitudinal" and "lateral" are generally in reference to a standard aircraft orientation. For example, longitudinal features may be generally aligned with the aircraft's primary direction of travel while lateral features may extend horizontally perpendicular to the aircraft's primary direction of travel.

Turning to FIGS. **1-3**, a cascade assembly **100** constructed in accordance with an embodiment of the invention is illustrated. The cascade assembly **100** broadly comprises a plurality of vanes **102**, a forward connection point **104**, an aft connection point **106**, and a rear support member **108**. The cascade assembly **100** may be part of a thrust reverser **200** configured to generate reverse thrust from an aircraft engine **202** via a reverse thrust flow opening **204**.

The plurality of vanes **102** may include a plurality of longitudinal panels **110** and a plurality of lateral panels **112**. The plurality of vanes **102** form several channels **114** for redirecting fan duct flow through the reverse thrust flow opening **204** when the thrust reverser is in a deployed configuration and the plurality of vanes **102** are distended. The plurality of vanes **102** may be formed of a pliable textile material such as ripstop woven fabric or ballistic nylon. To that end, the plurality of vanes **102** may be joined via at least one of overlap seams, double line stitching, and directional stitching to limit deflection, increase stiffness, provide local stress relief, mitigate damage propagation, and reinforce the longitudinal panels **110** and lateral panels **112**. Varying stitching orientation and spacing may increase resistance to stretching and locally re-enforce the longitudinal panels **110** and lateral panels **112**. Each of the plurality of vanes **102** may have different depths to optimize flow redirection or to optimize material usage.

The plurality of vanes **102** may also include stiffening means such as flexible or rigid battens, cording, or webbing for shape reinforcement or to facilitate distension of the plurality of vanes **102**. Heavier weave fabrics or multiple layers of fabric may tailor stiffness of portions of the plurality of vanes **102**. Local areas of stiffness may be employed to promote folding near less stiff portions of the plurality of vanes **102** when the cascade assembly **100** is stowed.

The plurality of vanes **102** may also include semi-rigid or rigid inserts in portions to form upper and lower portions flow-redirecting shapes. The upper and lower portions may be connected by relatively flexible portions, thereby forming a fabric hinge.

The plurality of vanes **102** may include any number of vanes. In one embodiment, the plurality of vanes **102** include seventy-two vanes in a rectangular array of eight vanes by nine vanes. The plurality of vanes **102** may also include varying depth thicknesses depending on their position in the array. For example, vanes in the middle of the array maybe deeper than vanes near sides of the array.

The longitudinal panels **110** extend from a forward end of the cascade assembly **100** to an aft end of the cascade assembly **100**. In one embodiment, the longitudinal panels **110** may be substantially straight to have virtually no redirecting effect on the fan duct flow or to minimize a lateral component of the fan duct flow. Alternatively, the longitudinal panels **110** may be curved to increase a lateral component of the fan duct flow. The longitudinal panels **110** may improve fluid flow by promoting laminar fluid flow or turbulent fluid flow.

The lateral panels **112** extend from one side of the cascade assembly **100** to an opposite side of the cascade assembly **100**. The lateral panels **112** may be curved to redirect the fan duct flow at least partially forward out of the reverse thrust flow opening **204**.

The forward connection point **104** connects the plurality of vanes **102** to a forward structure **206** of the thrust reverser **200**. The forward connection point **104** may have a fixed spacing from the aft connection point **106**. Alternatively, the forward connection point **104** may be movable relative to the aft connection point **106** to longitudinally expand the plurality of vanes **102** when the thrust reverser **200** is deployed. In one embodiment, the forward connection point **104** spans a forward edge of the plurality of vanes **102** or is one of several discrete connection points. The forward connection point **104** may also be or include a rigid mount integrated throughout the plurality of vanes **102**.

The aft connection point **106** connects the plurality of vanes **102** to the rear support member **108**. The aft connection point **106** may have a fixed spacing from the forward connection point **104**. Alternatively, the aft connection point **106** may be movable relative to the forward connection point **104** to longitudinally expand the plurality of vanes **102** when the thrust reverser **200** is deployed. In one embodiment, the aft connection point **106** spans a rear edge of the plurality of vanes **102** or is one of several discrete connection points. The aft connection point **106** may also be or include a rigid mount integrated throughout the plurality of vanes **102**.

The rear support member **108** may be connected to the plurality of vanes **102** at the aft connection point **106** and may be positioned in an open-ended chamber **208** of a sleeve

210 of the thrust reverser **200**. The rear support member **108** may be stationary relative to movement of the sleeve **210** when the thrust reverser **200** is actuated to a deployed configuration.

In one embodiment, the cascade assembly **100** may be heated via a tap feeding off the fan duct, a small volume of tempered bleed air off the engine **202**, or electrically powered heaters. This may ensure proper distension of the plurality of vanes **102** at low ambient temperatures.

The cascade assembly **100** may also be integrated together with other cascade assemblies to create a single cascade assemblage instead of a series of discrete, spaced apart cascade assemblies. The cascade assemblage may be attached to the thrust reverser **200** at several attachment locations or via segmented rigid mounting flanges. Segmented mounting may employ interspaced flexible portions that facilitate collapsing of the cascade assemblage into a reduced volume for storage or shipping.

In use, the cascade assembly **100** redirects fan duct flow when the thrust reverser **200** is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve **210** shifts rearward relative to the forward structure **206** to create the reverse thrust flow opening **204** and expose the cascade assembly **100** in the reverse thrust flow opening **204**. A blocker door **214** also blocks off a forward thrust flow path **212** to redirect fan duct flow to the reverse thrust flow opening **204**. The fan duct flow passes through the channels **114** to distend the plurality of vanes **102**. The distended plurality of vanes **102** turn the fan duct flow to have a forward component, thereby decelerating the aircraft.

The plurality of vanes **102** collapse when the thrust reverser **200** is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve **210** shifts toward the forward structure **206** to close off the reverse thrust flow opening **204**. The pliable textile material allows the plurality of vanes **102** to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber **208**. To that end, the plurality of vanes **102** may collapse along a single plane or axis or in at least two directions. The sleeve **210** may also facilitate collapse of the plurality of vanes **102** via funneling features or geometry.

The above-described cascade assembly **100** provides several advantages. For example, the textile cascade assembly **100** is lightweight and can be stowed in a small space. This allows for a reduction of engine nacelle diameter and weight and hence a reduction of aerodynamic drag. Smaller engine supports can also be used to support the smaller engines, further reducing weight and aerodynamic drag. The plurality of vanes **102** of the cascade assembly **100** may be longer or have more complex shapes, which may increase reverse thrust. The plurality of vanes **102** may also be easier to manufacture.

Turning to FIG. **4**, a cascade assembly **300** constructed in accordance with another embodiment of the invention is illustrated. The cascade assembly **300** broadly comprises a plurality of vanes **302**, a forward connection point **304**, an aft connection point **306**, and a rear support member **308**. The cascade assembly **300** may be part of a thrust reverser **400** configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening **402**.

The plurality of vanes **302** may include a plurality of longitudinal panels **310** and a plurality of lateral panels **312**. The plurality of vanes **302** form several channels **314** for redirecting fan duct flow through the reverse thrust flow opening **402** when the thrust reverser is in a deployed configuration and the plurality of vanes **302** are distended.

Some of the plurality of vanes **302** (aft vanes in particular) may be closed-end cells configured to inflate instead of allow duct flow to pass through. Lateral panels **312** of the closed-end cells may form a blocker panel **316**. The blocker panel **316** contacts an inner wall **404** of the thrust reverser **400** when the closed-end cells are inflated. The blocker panel **316** may include flexible, semi-rigid, or rigid material. In this way, the blocker panel **316** aids in cascade distension, flow redirection, and cascade support. The blocker panel **316** may cooperate with features on a sleeve of the thrust reverser **400** for stowing the cascade assembly **300**. That is, the blocker panel **316** may be constructed to facilitate folding of the plurality of vanes **302** to be stowed in an open-ended chamber **408** of the sleeve **410**.

The forward connection point **304** connects the plurality of vanes **302** to a forward structure **406** of the thrust reverser **400**. In one embodiment, the forward connection point **304** spans a forward edge of the plurality of vanes **302**. Alternatively, the forward connection point **304** is one of several discrete connection points. The forward connection point **304** may also be or include a rigid mount integrated throughout the plurality of vanes **302**.

The aft connection point **306** connects the plurality of vanes **302** to the rear support member **308**. In one embodiment, the aft connection point **306** spans a rear edge of the plurality of vanes **302**. Alternatively, the aft connection point **306** may be one of several discrete connection points. The aft connection point **306** may also be or include a rigid mount integrated throughout the plurality of vanes **302**.

The rear support member **308** may be connected to the plurality of vanes **302** at the aft connection point **306** and may be positioned in an open-ended chamber **408** of the sleeve **410**. The rear support member **308** may be stationary relative to movement of the sleeve **410** when the thrust reverser **400** is actuated to a deployed configuration.

In use, the cascade assembly **300** redirects fan duct flow when the thrust reverser **400** is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve **410** shifts rearward relative to the forward structure **406** to create the reverse thrust flow opening **402** and expose the cascade assembly **300** in the reverse thrust flow opening **402**. Some of the plurality of vanes **302** inflate so that the blocker panel **316** blocks off a forward thrust flow path **412** to redirect fan duct flow to the reverse thrust flow opening **402**. The fan duct flow passes through the channels **314** to distend the plurality of vanes **302**, or they may be distended due to the aforementioned vane inflation. The distended plurality of vanes **302** turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The plurality of vanes **302** collapse when the thrust reverser **400** is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve **410** shifts toward the forward structure **406** to close off the reverse thrust flow opening **402**. The pliable textile material allows the plurality of vanes **302** to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber **408**.

Turning to FIG. **5**, a cascade assembly **500** constructed in accordance with another embodiment of the invention is illustrated. The cascade assembly **500** broadly comprises a plurality of vanes **502**, a forward connection point **504**, an aft connection point **506**, a rear support member **508**, and a plurality of biasing members **510**. The cascade assembly **500** may be part of a thrust reverser **600** configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening **602**.

The plurality of vanes **502** include a plurality of longitudinal panels **512** and a plurality of lateral panels **514**. The plurality of vanes **502** form several channels **516** for redirecting fan duct flow through the reverse thrust flow opening **602** when the thrust reverser **600** is in a deployed configuration and the plurality of vanes **502** are distended.

The forward connection point **504** connects the plurality of vanes **502** to a forward structure **604** of the thrust reverser **600**. In one embodiment, the forward connection point **504** spans a forward edge of the plurality of vanes **502**. Alternatively, the forward connection point **504** may be one of several discrete connection points. The forward connection point **504** may also be or include a rigid mount integrated throughout the plurality of vanes **502**.

The aft connection point **506** connects the plurality of vanes **502** to a sleeve **608** of the thrust reverser **600**. In one embodiment, the aft connection point **506** spans a rear edge of the plurality of vanes **502**. Alternatively, the aft connection point **506** may be one of several discrete connection points. The aft connection point **506** may also be or include a rigid mount integrated throughout the plurality of vanes **502**.

The rear support member **508** may be connected to the plurality of vanes **502** at the aft connection point **506** and may be positioned in an open-ended chamber **606** of the sleeve **608**. The rear support member **508** may be stationary relative to movement of the sleeve **608** when the thrust reverser **600** is actuated to a deployed configuration.

The biasing members **510** may be spaced apart from each other throughout the plurality of vanes **502** and may be sewn in or embedded in the lateral panels **514**. The biasing members **510** may be compressed, coiled, or stressed when the plurality of vanes **502** are stowed. The biasing members **510** may be leaf springs, coil springs, torsion springs, or the like. The biasing members **510** urge the plurality of vanes **502** to a distended position when the thrust reverser **600** is deployed. The biasing members **510** may also stabilize and reinforce the longitudinal panels **512** and lateral panels **514** and reinforce a shape of the lateral panels **514**.

In use, the cascade assembly **500** redirects fan duct flow when the thrust reverser **600** is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve **608** shifts rearward relative to the forward structure **604** to create the reverse thrust flow opening **602** and expose the cascade assembly **500** in the reverse thrust flow opening **602**. A blocker door **612** also blocks off a forward thrust flow path **610** to redirect fan duct flow to the reverse thrust flow opening **602**. The biasing members **510** expand, uncoil, or relax to distend the plurality of vanes **502** in the reverse thrust flow opening **602**. The distended plurality of vanes **502** turn the fan duct flow to have a forward component, thereby decelerating the aircraft.

The plurality of vanes **502** collapse when the thrust reverser **600** is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve **608** shifts toward the forward structure **604** to close off the reverse thrust flow opening **602**. The pliable textile material allows the plurality of vanes **502** to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber **606**. The biasing members **510** are recompressed, recoiled, or restressed as the plurality of vanes **502** are stowed.

Turning to FIG. **6**, a cascade assembly **700** constructed in accordance with another embodiment of the invention is illustrated. The cascade assembly **700** broadly comprises a plurality of vanes **702**, a forward connection point **704**, an aft connection point **706**, and a forward support member **708**. The cascade assembly **700** may be part of a thrust reverser **800** configured to generate reverse thrust from an aircraft engine **802** via a reverse thrust flow opening **802**.

The plurality of vanes **702** include a plurality of longitudinal panels **710** and a plurality of lateral panels **712**. The plurality of vanes **702** form several channels **714** for redirecting fan duct flow through the reverse thrust flow opening **802** when the thrust reverser **800** is in a deployed configuration and the plurality of vanes **702** are distended.

The forward connection point **704** connects the plurality of vanes **702** to the forward support member **708**. In one embodiment, the forward connection point **704** spans a forward edge of the plurality of vanes **702**. Alternatively, the forward connection point **704** may be one of several discrete connection points. The forward connection point **704** may also be or include a rigid mount integrated throughout the plurality of vanes **702**.

The aft connection point **706** connects the plurality of vanes **702** to a sleeve **804** of the thrust reverser **800**. In one embodiment, the aft connection point **706** spans a rear edge of the plurality of vanes **702**. Alternatively, the aft connection point **706** may be one of several discrete connection points. The aft connection point **706** may also be or include a rigid mount integrated throughout the plurality of vanes **702**.

The forward support member **708** may be connected to the plurality of vanes **702** at the forward connection point **706** and may be positioned in an open-ended chamber **806** of a forward structure **808** of the thrust reverser **800**. The forward support member **708** may be configured to move at least somewhat in unison with the sleeve **804** of the thrust reverser **800** when the thrust reverser **800** is actuated to a deployed configuration. To that end, the forward support member **708** may translate within the open-ended chamber **806** during thrust reverser actuation.

In use, the cascade assembly **700** redirects fan duct flow when the thrust reverser **800** is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve **804** shifts rearward relative to the forward structure **808** to create the reverse thrust flow opening **802** and to draw the cascade assembly **700** out of the open-ended chamber **806** of the forward structure **808**. A blocker door **812** also blocks off a forward thrust flow path **810** to redirect fan duct flow to the reverse thrust flow opening **802**. The fan duct flow passes through the channels **714** to distend the plurality of vanes **702**. The distended plurality of vanes **702** turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The plurality of vanes **702** collapse when the thrust reverser **800** is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve **804** shifts toward the forward structure **808** to close off the reverse thrust flow opening **802**. The pliable textile material allows the plurality of vanes **702** to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber **806**. The pliable textile material reduces the storage space needed, which allows the plurality of vanes **702** to be stowed in the forward structure **1004** and decreases the overall size of the engine's nacelle.

Turning to FIG. **7**, a cascade assembly **900** constructed in accordance with another embodiment of the invention is illustrated. The cascade assembly **900** broadly comprises a plurality of vanes **902**, a forward connection point **904**, an aft connection point **906**, a rear support member **908**, an inflation scoop **910**, and an inflation tube **912**. The cascade assembly **900** may be part of a thrust reverser **1000** configured to generate reverse thrust from an aircraft engine via a reverse thrust flow opening **1002**.

The plurality of vanes **902** include a plurality of longitudinal panels **914** and a plurality of lateral panels **916**. The plurality of vanes **902** form several channels **918** for redirecting fan duct flow through the reverse thrust flow opening **1002** when the thrust reverser **1000** is in a deployed configuration and the plurality of vanes **902** are distended.

The forward connection point **904** connects the plurality of vanes **902** to a forward structure **1004** of the thrust reverser **1000**. In one embodiment, the forward connection point **904** spans a forward edge of the plurality of vanes **902**. Alternatively, the forward connection point **904** may be one of several discrete connection points. The forward connection point **904** may also be or include a rigid mount integrated throughout the plurality of vanes **902**.

The aft connection point **906** connects the plurality of vanes **902** to a sleeve **1008** of the thrust reverser **1000**. In one embodiment, the aft connection point **906** spans a rear edge of the plurality of vanes **902**. Alternatively, the aft connection point **906** may be one of several discrete connection points. The aft connection point **906** may also be or include a rigid mount integrated throughout the plurality of vanes **902**.

The rear support member **908** may be connected to the plurality of vanes **902** at the aft connection point **906** and may be positioned in an open-ended chamber **1006** of the sleeve **1008**. The rear support member **908** may be stationary relative to movement of the sleeve **1008** when the thrust reverser **1000** is actuated to a deployed configuration. To that end, the rear support member **908** may translate within the open-ended chamber **1006** during thrust reverser actuation.

The inflation scoop **910** may be a modified vane near the front of the cascade assembly **900** and may be connected to the inflation tube **912** for directing some fluid flow into the inflation tube **912**. To that end, the inflation scoop **910** may extend lower than the plurality of vanes **902** near the forward support structure **1004**.

The inflation tube **912** may be fluidly connected between the inflation scoop **910** and some of the plurality of vanes **902**. To that end, the inflation tube **912** may include a plurality of openings **920** for distributing the fluid flow collected by the inflation scoop **910** to the connected vanes **902**. In one embodiment, the inflation tube **912** extends from the inflation scoop **910** near the front of the cascade assembly **900** to an aft end of the cascade assembly **900** with the openings **920** passing through certain longitudinal panels **914**.

In use, the cascade assembly **900** redirects fan duct flow when the thrust reverser **1000** is actuated from a stowed configuration to a deployed configuration. Specifically, the sleeve **1008** shifts rearward relative to the forward structure **1004** to create the reverse thrust flow opening **1002** and expose the cascade assembly **900** in the reverse thrust flow opening **1002**. A blocker door **1012** also blocks off a forward thrust flow path **1010** to redirect fan duct flow to the reverse thrust flow opening **1002**. The inflation scoop **910** directs some of the fan duct flow into the inflation tube **912**. The inflation tube **912** distributes the fan duct flow collected by the inflation scoop **910** to some of the plurality of vanes **902** via the openings **920** to distend the plurality of vanes **902**. The distended plurality of vanes **902** turn the fan duct flow to have a forward component thereby decelerating the aircraft.

The plurality of vanes **902**, inflation scoop **910**, and inflation tube **912** collapse when the thrust reverser **1000** is actuated from the deployed configuration to the stowed configuration. Specifically, the sleeve **1008** shifts toward the forward structure **1004** to close off the reverse thrust flow opening **1002**. The pliable textile material allows the plurality of vanes **902**, inflation scoop **910**, and inflation tube **912** to fold, crease, roll, scrunch, twist, curl, crease, compress, or pack into the open-ended chamber **1006**. Alternatively, the inflation scoop **910** may be fixed and fit within the chamber **1006**.

Although the invention has been described with reference to the preferred embodiment illustrated in the attached drawing figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

Having thus described various embodiments of the invention, what is claimed as new and desired to be protected by Letters Patent includes the following:

1. A cascade assembly for a thrust reverser, the cascade assembly comprising:

a plurality of pliable textile vanes including a plurality of longitudinal panels and a plurality of lateral panels cooperatively forming a plurality of channels, the plurality of pliable textile vanes being shiftable between a collapsed position when the thrust reverser is in a stowed configuration and a distended position when the thrust reverser is in a deployed configuration to redirect fan duct flow,

the plurality of longitudinal panels and the plurality of lateral panels being configured to pliably distend via the fan duct flow passing through the plurality of channels when the thrust reverser is actuated from the stowed configuration to the deployed configuration so that the plurality of lateral panels achieve a fan duct flow redirecting curvature in transitioning to the distended position and pliably collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration so that the plurality of lateral panels lose the fan duct flow redirecting curvature in transitioning to the collapsed position,

the plurality of pliable textile vanes having at least two different depths when the plurality of pliable textile vanes are in the distended position.

2. The cascade assembly of claim **1**, the pliable textile vanes being made of ripstop material.

3. The cascade assembly of claim **1**, the cascade assembly further comprising a plurality of battens configured to reinforce a shape of the plurality of pliable textile vanes when the plurality of pliable textile vanes are distended.

4. The cascade assembly of claim **1**, the plurality of pliable textile vanes including directional reinforcement stitching.

5. The cascade assembly of claim **1**, the plurality of pliable textile vanes including semi-rigid or rigid portions.

6. A cascade assembly for a thrust reverser, the cascade assembly comprising:

a plurality of pliable textile vanes including a plurality of longitudinal panels and a plurality of lateral panels cooperatively forming a plurality of channels, the plurality of pliable textile vanes being shiftable between a collapsed position when the thrust reverser is in a stowed configuration and a distended position when the thrust reverser is in a deployed configuration to redirect fan duct flow,

the plurality of longitudinal panels and the plurality of lateral panels being configured to pliably distend via the fan duct flow passing through the plurality of channels when the thrust reverser is actuated from the stowed configuration to the deployed configuration so that the plurality of lateral panels achieve a fan duct flow redirecting curvature in transitioning to the distended position and pliably collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration so that the plurality of lateral panels lose the fan duct flow redirecting curvature in transitioning to the collapsed position,

the plurality of pliable textile vanes having at least two different depths when the plurality of pliable textile vanes are in the distended position and a maximum collapsed depth smaller than the at least two different depths when the plurality of pliable textile vanes are in the collapsed position.

7. A cascade assembly for a thrust reverser including a forward structure and a sleeve having an open-ended chamber, the cascade assembly comprising:

a plurality of pliable textile vanes including a plurality of substantially straight longitudinal panels and a plurality of lateral panels cooperatively forming a plurality of channels, the plurality of pliable textile vanes being shiftable between a collapsed position when the thrust reverser is in a stowed configuration and a distended position when the thrust reverser is in a deployed configuration to redirect fan duct flow,

the plurality of longitudinal panels and the plurality of lateral panels being configured to pliably distend via the fan duct flow passing through the plurality of channels when the thrust reverser is actuated from the stowed configuration to the deployed configuration so that the plurality of lateral panels achieve a fan duct flow redirecting curvature in transitioning to the distended position and pliably collapse when the thrust reverser is actuated from the deployed configuration to the stowed configuration so that the plurality of lateral panels lose the fan duct flow redirecting curvature in transitioning to the collapsed position,

the plurality of pliable textile vanes having at least two different depths when the plurality of pliable textile vanes are in the distended position and a maximum collapsed depth smaller than the at least two different depths when the plurality of pliable textile vanes are in the collapsed position;

a forward connection point configured to connect the plurality of pliable textile vanes to the forward structure;

a rear support member configured to be positioned in the open-ended chamber; and

an aft connection point opposite the forward connection point and configured to connect the plurality of pliable textile vanes to the rear support member.

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